# Defining Favourable Reference Values for the Svalbard Breeding Population of the Pink-Footed Goose (*Anser brachyrhynchus*)

AEWA European Goose Management Platform

**EGMP Technical Report No.27**

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AEWA

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***EGMP Technical Report No. 27***

*Prepared by the AEWA European Goose Management Platform Data Centre*

**Compiled by:** Jesper Madsen[1,2], Claus Lunde Pedersen[1], Ingunn Tombre[3], Jeroen Nienhuis[4], Kees Koffijberg[4] and Kees H.T. Schreven[5]

[1]Aarhus University, Department of Ecoscience, Denmark
[2]AEWA European Goose Management Platform Data Centre, Aarhus University, Denmark
[3]Norwegian Institute for Nature Research
[4]Sovon Vogelonderzoek, the Netherlands
[5]Netherlands Institute of Ecology

**With contributions from:** Szabolcs Nagy (Wetlands International) and Melissa Lewis (UNEP/AEWA Secretariat)

**Produced with financial support from:** The Danish Agency for Green Transition and Aquatic Environment

**Acknowledgments:** Thanks to Eckhart Kuijken, Christine Verscheure, Paul Shimmings and the European Commission for providing information and comments.

**Milestones in production of the report:**

8-9 October 2024: Workshop for the Revision of the Pink-footed Goose International Single Species Management Plan (ISSMP) held in Levanger, Norway
6 June 2025: Favourable reference values (FRVs) proposal circulated to workshop participants
27 June 2025: 1st revision of FRVs proposal circulated to workshop participants
4 July 2025: 2nd revision of FRVs proposal circulated to AEWA Technical Committee
23 July 2025: 2nd revision of FRVs proposal circulated to Range State governments
31 October 2025: Draft FRVs report published in advance of the 9th Session of the Meeting of the Parties to AEWA (MOP9)
11-14 November 2025: Revised Pink-footed Goose ISSMP adopted by AEWA MOP9

**Photo cover:** © Magnus Elander

**Recommended citation**: Madsen, J., Pedersen, C.L., Tombre, I., Nienhuis, J., Koffijberg, K. & Schreven, K.H.T. (2025). Defining Favourable Reference Values for the Svalbard (br) Population of the Pink-footed Goose (*Anser brachyrhynchus*). EGMP Technical Report No. 27, Bonn, Germany.

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## Table of Contents

List of Abbreviations ..... 5
Summary ..... 6
1. Introduction ..... 6
2. Review of existing information ..... 7
2.1. Current and past distribution ..... 7
2.1.1. Breeding ..... 7
2.1.2 Moulting ..... 8
2.1.3 Post-breeding ..... 9
2.1.4 Passage and wintering ..... 9
2.2 Habitat availability ..... 10
2.2.1 Breeding habitat ..... 10
2.2.2 Staging habitat ..... 11
2.2.3 Wintering habitat ..... 11
2.3 Past and current population sizes ..... 11
3. Trend, major shifts, pressures ..... 14
4. Setting Favourable Reference Values ..... 14
4.1 Favourable Reference Population ..... 14
4.2 Favourable Reference Range ..... 16
4.3 Favourable Reference Habitat ..... 21
4.4 Proposed Favourable Reference Values ..... 21
Literature ..... 23

## List of Abbreviations

| | |
|---|---|
| AEWA | Agreement on the Conservation of African-Eurasian Migratory Waterbirds |
| AFMP | Adaptive Flyway Management Programme |
| AV | Agreement Value |
| CMS | Convention on the Conservation of Migratory Species of Wild Animals |
| EGMP | European Goose Management Platform under AEWA |
| ISSAP | International Single Species Action Plan |
| ISSMP | International Single Species Management Plan |
| FCS | Favourable Conservation Status |
| FRH | Favourable Reference Habitat |
| FRP | Favourable Reference Population |
| FRR | Favourable Reference Range |
| FRV | Favourable Reference Values |
| MOP | Meeting of the Parties to AEWA |
| Ne | Effective population size |

## Summary

This document presents a technical description of how Favourable Reference Values (FRVs) were derived under the African-Eurasian Migratory Waterbird Agreement (AEWA) for the Svalbard (br) population of the Pink-footed Goose. This population is subject to an International Single Species Management Plan (ISSMP), which was first adopted by the 5th session of AEWA Meeting of the Parties (MOP5) in 2012. A revised version of the ISSMP, including FRVs, was adopted by AEWA MOP9 held on 11-14 November 2025.

According to the reference-based approach to define the Favourable Reference Population (FRP) for the Svalbard (br) population of the Pink-footed Goose, the FRP is set at a spring population size of 49,000 individuals, i.e., the closest available value after the date that AEWA entered into force on 1 November 1999 (i.e. the Agreement Value – AV). By that time, the population was flourishing in exponential growth and was expanding its range on the breeding and non-breeding grounds. Habitat was not limiting the population, as new habitat became available on the breeding grounds due to global warming as well as on the non-breeding grounds due to beneficial changes in agricultural land use practices. At this Agreement Value the population plays a key role in the Arctic ecosystems. The increasing abundances exert an increasing grazing pressure on the Svalbard tundra, of concern to its ecosystem functions. In the non-breeding range, the population is heavily reliant on artificial agricultural habitat, which has caused socio-economic conflicts. The range used in 2000 was sufficient to maintain the population and its ecosystem services throughout the annual cycle, including opportunities for recreational observation and use. The population's range at that time (i.e. AV) is therefore used to determine the Favourable Reference Range (FRR) at a total of 41,400 $km^2$ for the breeding range (Svalbard) and 374,600 $km^2$ for the non-breeding land range and 835,100 $km^2$ including seas crossed on migration.


## 1. Introduction

The goal of the 2012 version of the International Single Species Management Plan (ISSMP) for the Pink-footed Goose was "To maintain the favourable conservation status of the Svalbard (br) Pink-footed Goose population at flyway level while taking into account economic and recreational interests" (Madsen & Williams 2012).[1] The goal included in the revised ISSMP is "To maintain the favourable conservation status of the Svalbard (br) Pink-footed Goose population at flyway level while taking into account ecological, socio-economic and recreational interests".

At the time of the adoption of the ISSMP by the Meeting of the Parties (MOP) to AEWA in 2012, there existed no guidance or established procedures for defining Favourable Conservation Status (FCS) under AEWA. AEWA still lacks MOP-adopted guidance on this topic. However, in 2017 the AEWA Technical Committee endorsed a short provisional guidance document on the interpretation of FCS. Moreover, in the period since the Pink-footed Goose ISSMP's adoption, the processes to develop ISSMPs and Adaptive Flyway Management Programmes (AFMPs) for Barnacle Goose and Greylag Goose (implemented in 2018) under the European Goose Management Platform (EGMP) produced detailed, species-specific discussion papers to inform the definition of FCS of the target populations. Favourable Reference Values (FRVs) were used as measurable indicators that describe hypotheses about the size of the population, its distribution and the availability and quality of habitat that describe the FCS (Doc. AEWA/EGMIWG/Inf.5.12). The Format and Guidelines for AEWA International Single and Multi-species Management Plans (first adopted by AEWA MOP8, with revisions submitted to MOP9) envision that FRVs will be established for each population covered by an ISSMP, and that these will be established in accordance with the Convention on Migratory Species' definition of FCS.

[1] Throughout this document the population is termed as the Svalbard (br) population for briefness even if the breeding range has expanded and it currently also breeds on Novaya Zemlya.

The key concepts and considerations for defining FCS and FRVs are described in Doc. AEWA/EGMIWG/Inf.5.11 and will not be repeated here. The treatment follows the protocol applied for the Barnacle Goose and the Greylag Goose. It should be noted that the purpose of this document is only to define FRVs, i.e. the parameters of FCS for the population. Assessing the conservation status will be carried out periodically during the implementation of the Adaptive Flyway Management Programme. Those assessments will use the FRVs agreed in the revised ISSMP together with information on trends in the FRVs and information on future prospects.

## 2. Review of existing information

The Pink-footed Goose occurs in two biogeographic populations:

***The Svalbard breeding population***, traditionally staging and wintering in Norway, Denmark, The Netherlands and Belgium. Within the last two decades, Pink-footed Geese have also colonized Novaya Zemlya in North Russia, using staging areas in Finland and Sweden, and wintering in Denmark, the Netherlands and Belgium (Madsen et al. 2023).

***The Iceland/East Greenland breeding population*****,** wintering in the British Isles. This population has steadily increased from c. 20,000-30,000 in the 1950s (Mitchell et al. 1999) to c. 500,000 individuals in around 2020 (Wetlands International 2024).

The two populations of Pink-footed Geese are demographically distinct. Annually, some hundreds of individuals exchange, but the vast majority either return to their original population or appear to succumb in the new environment (Madsen et al. 2014). The populations are also genetically distinct (Ruokonen, Aarvak & Madsen 2005; Pujolar et al. 2017), but a low degree of gene flow exists, suggesting a low degree of interchange in both directions, but one order of magnitude higher from Svalbard to Iceland than in the opposite direction. It is estimated that for every generation, on average one individual effectively migrated from the eastern to the western population (Pujolar et al. 2017).

The 2012 ISSMP only covers the Svalbard breeding population, while the revised plan also includes the new range expansion to Novaya Zemlya in Russia, Finland and Sweden.

### 2.1. Current and past distribution

#### 2.1.1. Breeding

The main breeding grounds are found in Svalbard. Bear Island in the Barents Sea also hosts colonies and in recent years, scattered pairs have been found breeding in Finnmark in Northern Norway (https://ebba2.info/maps/species/Anser-brachyrhynchus/ebba1/breeding/); however, there has been no systematic survey to document the distribution and number of breeding pairs. Within the last two decades, Pink-footed Geese have colonized Novaya Zemlya in North Russia, mainly nesting in the southwestern part of Severny Island (Madsen et al. 2023).

In Svalbard, the core known breeding area is situated in the western part of Spitsbergen, including the fjords and coastal lowlands (Norderhaug 1971; Madsen et al. 1999; GOOSEMAP 2012; https://goosemap.nina.no/goosemap/). Since the 1960s, the range has expanded to the north and east, including scattered pairs nesting on Edgeøya (Fig. 1). Within the historic range, local nesting colonies have expanded, also altitudinally, and new valleys have been occupied. The timing of snow melt is a key factor defining the availability of suitable nest sites, usually positioned on southfacing slopes (Anderson et al. 2014). With the ongoing fast global warming in the Arctic, that is particularly amplified for the Barents Sea region (Isaksen et al. 2022), the area of suitable habitat has increased. Based on nest distribution data and climate-environmental

information from the early 2000s, a predictive spatial model forecasted that with a 1ºC and a 2ºC increase in summer temperatures, the area of highly suitable habitat would increase by 84 % and 217 %, respectively (Jensen et al. 2008). According to temperature observations and re-analyses, the summer temperatures in western Svalbard have increased significantly with 0.5ºC/decade during 2001-2020 (Isaksen et al. 2022). Hence, so far, the 1ºC increase scenario has played out, suggesting that the suitable habitat has almost doubled within two decades. With continued warming, it is expected that the range will increase even further.

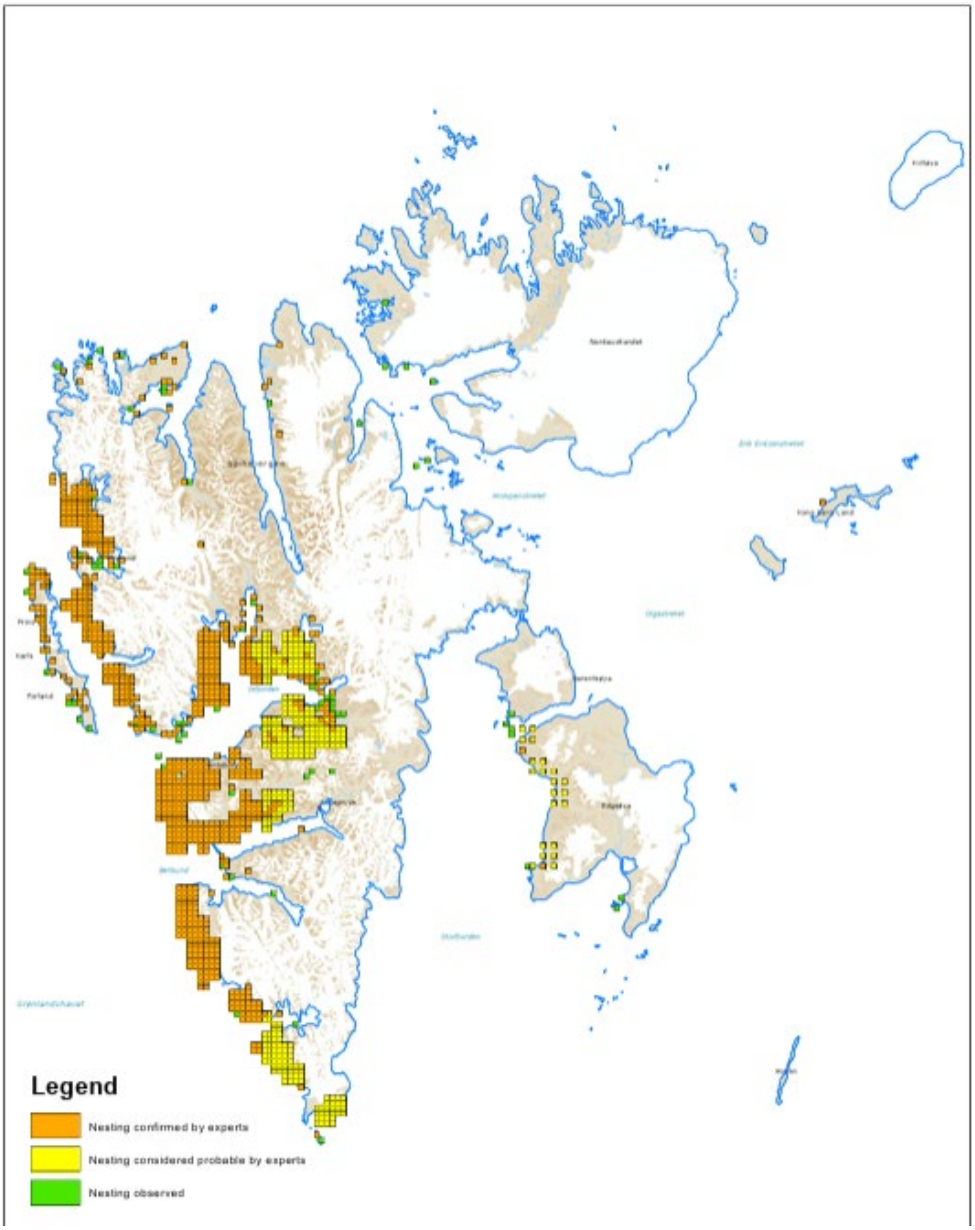



***Figure 1.*** *Distribution of nesting Pink-footed Geese in Svalbard in 10 km x 10 km grid cells, recorded in the GOOSEMAP website (https://goosemap.nina.no/goosemap/), representing observations until 2011.*

### 2.1.2 Moulting

Non-breeders and failed breeders of Pink-footed Geese in Svalbard depart from the breeding areas and undertake a moult migration to the northern and eastern parts of Svalbard (Glahder at al. 2007). There they shed remiges and are flightless for c. four weeks. They congregate along shallow coastlines or on larger lakes (see GOOSEMAP 2012 for distribution). On Novaya Zemlya, non-breeding geese moult along the shores of Severny Island (based on GPS-tracking; K. Schreven and J. Madsen unpubl. data).

### 2.1.3 Post-breeding

After fledging of the young, the families of the Svalbard Pink-footed Geese either stay in the vicinity of the brood-rearing areas or move to the east part (primarily Edgeøya) (see GOOSEMAP 2012; backed by GPS-tracking of families; K. Schreven and J. Madsen unpubl. data).

### 2.1.4 Passage and wintering

The historic migratory pathway and staging and wintering areas have been reviewed by Madsen et al. (1999). In the middle of the 20th century, Pink-footed Geese had their main wintering grounds in the German Wadden Sea and Friesland in the Netherlands. The German sites were abandoned for unknown reasons, but the geese started to make increasing use of coastal polders of Flanders in Belgium, prompted by increased protection and creation of refuges for geese (Kuijken 1969). The main autumn and spring staging areas were found in western Jutland, Denmark (Madsen 1982), and geese only occurred in mild winters. In spring, the geese migrated from Denmark to Vesterålen in north Norway (Rikardsen 1982) and onwards to Svalbard. In autumn, geese flew from Svalbard to Norway but only stopped shortly in the mountains in Trøndelag before migrating to west Jutland and onwards to the wintering grounds. In the last 2-3 decades, geese have increasingly stayed in Denmark throughout the winter, facilitated by milder winters and profitable winter food conditions in terms of increasing areas with winter wheat fields (Therkildsen and Madsen 2000) and, more recently, growing of maize, with large amounts of highly profitable spilt resources (Clausen et al. 2018a). In consequence, fewer geese migrate south to the Netherlands, while wintering numbers in Flanders have remained relatively stable (Clausen et al. 2018b; Kuijken and Verscheure 2020, 2023). Both in the Netherlands and Belgium, the geese are also exploring maize stubble fields, which has led to an expansion of the wintering range in the two countries. Finally, geese have also started to exploit maize stubble fields in Schleswig-Holstein, Germany, but the numbers are not well-known (therefore, Germany is not regarded as a range state). In Denmark, geese fly up to 45 km inland from the west coast and north Jutland roost sites in search of maize stubble fields and, consequently, the staging area range has increased manifold.

In the 1980s, geese started to make a spring stopover in the Trøndelag lowlands around Trondheimsfjorden, before migrating to Vesterålen, and since the 1990s, the entire population appears to stay there, and the use of Vesterålen has decreased. The decreased use of Vesterålen is most likely caused by increasing food competition with Barnacle Geese, which have shifted their spring staging areas northwards along the Norwegian coast (Tombre et al. 2013; Tombre et al. 2020).

The Pink-footed Geese colonizing Novaya Zemlya have developed spring staging areas in the Oulu region in northwest Finland and in the Örebro region in south Sweden. In autumn, most of the geese migrate non-stop from Novaya Zemlya to Örebro, and only small flocks appear to make stopovers in Oulu and other sites. In late autumn, the geese from Örebro migrate further south to sites in Skåne and southeast Denmark, alternatively fly to west Jutland. They may fly to the Netherlands and Flanders, return to west Jutland, but then move back to Örebro in spring. Some geese migrate to Trøndelag in Norway and appear to migrate from there to Svalbard. Among the geese spring staging in Oulu, some birds migrate across Finnmark to Svalbard. As of 2025, there seems to be a group of geese which consistently migrate along the new migratory route and breed in Novaya Zemlya as well as a group which uses the new spring migration route on their way to Svalbard. Based on observation of marked birds, there continues to be a flow of individuals using the traditional and the new route, and the use of staging and wintering areas on the new route are still under development (Madsen et al. 2023; Fig. 2).

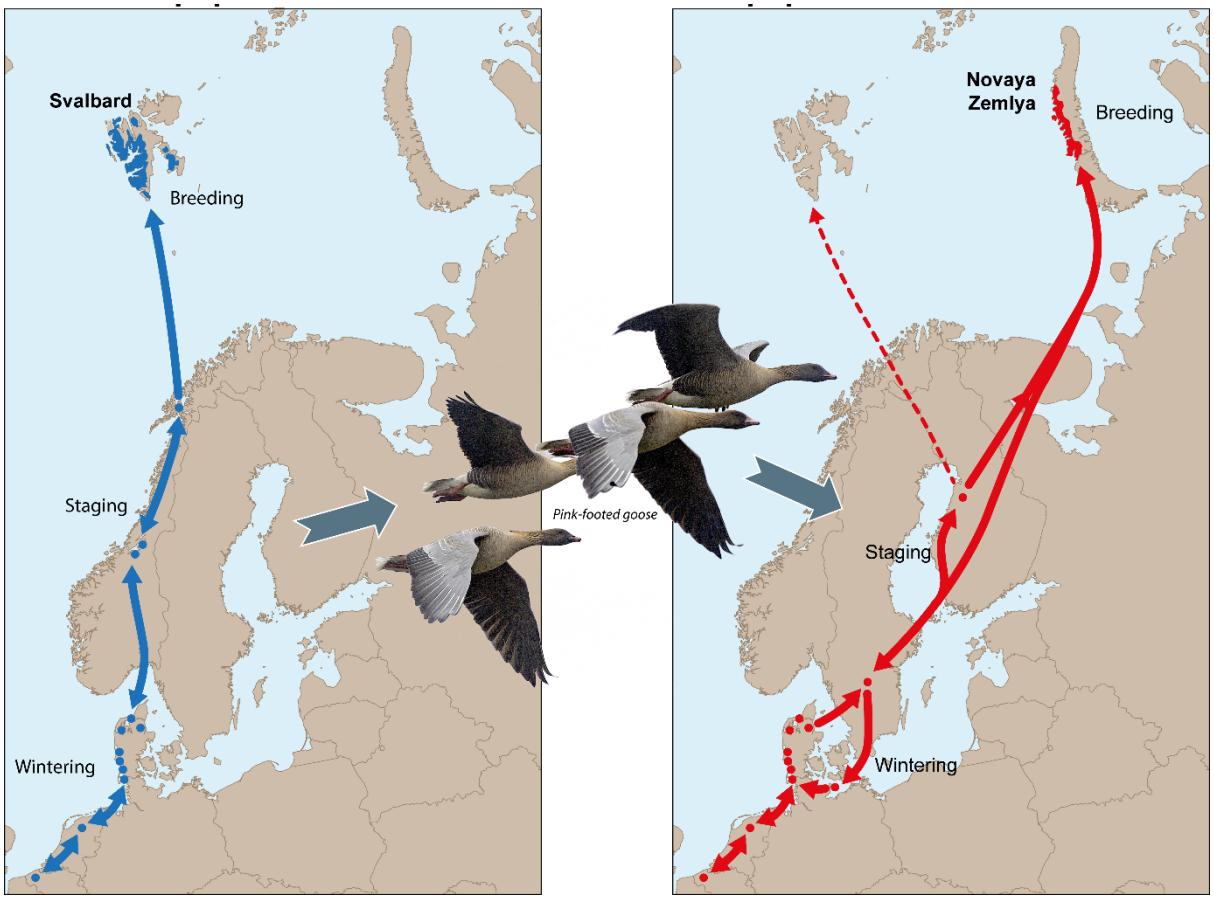



***Figure 2.*** *The traditional (left) and the newly developed (right) migration routes of Pink-footed Geese, with key sites and breeding grounds. Migrating geese illustrate that geese have switched from the traditional to the new migratory route (from Madsen et al. 2023; Current Biology).*

## 2.2 Habitat availability

### 2.2.1 Breeding habitat

On arrival in Svalbard in May (pre-nesting), the Pink-footed Geese forage in mesic moss-covered tundra areas. Here, the geese forage on roots and rhizomes of graminoids, dicots and Equisetum pulled out of the thawing moss carpets, so-called 'grubbing' (Fox, Francis & Bergersen 2006). In years with late snowmelt, these habitats are limited in availability, whereas in years with early snowmelt, this habitat is widely available (Eischeid et al. 2023).

The Pink-footed Geese nest on south-facing slopes in lowlands, under bird cliffs, on outcrops in wet tundra areas and on small islands close to the coast. The availability of nest sites varies with the timing of snow melt, and in years with late snow melt, this can cause failure in the breeding attempt of goose pairs, manifest at local colony levels (Madsen et al. 2007) and at the overall population level (Jensen et al. 2023). With the ongoing warming, there is an increasing tendency for earlier snowmelt which will positively influence nesting opportunities within the existing breeding range and open new opportunities in regions which have been unavailable so far (see above).

Foraging habitat for Pink-footed Geese has been sufficient for the increasing population; however, the extent and intensity of grubbing has increased (Ravolainen et al. in prep, see Madsen et al. 2024), and may negatively affect the food availability, because the time it takes for the vegetation to recover can last several years.

Post-hatching foraging habitats comprise lowland as well as upland wet, mesic and dry tundra areas. As families of Pink-footed Geese gather in flocks and walk far inland, the habitat appears not to be limited at present. To what extent the moulting habitats are sufficient is unknown. Likewise, the habitat availability during post-breeding is not clear, but there seems to be large areas of high-quality tundra areas in the east and south which are not used during the breeding and moulting periods but only exploited during post-breeding.

### 2.2.2 Staging habitat

Historically, Pink-footed Geese were constrained to very few staging sites along the migratory routes, possibly due to the fact that they were heavily persecuted in both autumn and spring. In Denmark, spring hunting was banned in 1965, and since then, spring habitats expanded along the Jutland west coast, while autumn habitats remained restricted to three sites (Madsen 1984). The geese utilized salt marshes, extensive grasslands but also farmland. Increasingly, geese switched to farmland foraging in autumn and spring, in autumn mainly using spilt grain or maize resources, in spring fertilized pastures, winter cereal fields and new-sown cereal fields (Fox et al. 2005).

In Norway, spring staging was historically restricted to Vesterålen, where geese primarily foraged on salt marshes and extensive grasslands (Rikardsen 1982). In recent decades these habitats have overgrown, and geese prefer to feed in fertilized pastures (Tombre et al. 2013). In Trøndelag, geese almost exclusively feed in farmland habitats, in autumn primarily in stubble fields, potato fields or fertilized pastures, in spring left over stubble fields, fertilized pastures and new-sown cereal fields (Chudzinski et al. 2016).

In Sweden and Finland, the Pink-footed geese forage in farmland habitats; in autumn mainly in stubble fields; in spring mainly in fertilized pastures, stubble fields and waste potato fields.

### 2.2.3 Wintering habitat

In the Netherlands and Belgium, the Pink-footed Geese traditionally forage in extensively farmed grasslands as well as fertilized pastures. In both countries the geese now also have spread to feed in maize stubble fields (Cottaar 2009; Kuijken & Verscheure 2020, 2023). In Denmark, wintering geese primarily forage in fields with waste maize, sugar beet (in SE Denmark), winter cereal fields and fertilised grasslands.

## 2.3 Past and current population sizes

Historic records of the Svalbard (br) Pink-footed Goose population size and trajectories go back to the 1930s (Madsen 1982) and, in a longer time perspective, demographic inference can be made based on whole genome and RAD sequencing data generated for the Pink-footed Goose (Pujolar et al. 2017; Pujolar et al. 2018). With this information, the demographic history going back to the last ice age can be established.

The genomic demographic history analyses suggest that the Pink-footed Goose population reached a low point during the last glaciation. The population might have occurred in refugia in parts of Iceland, whereas Svalbard was completely covered by ice, except for some nunataks (Pujolar et al. 2017). Following the retreat of the ice from around 25,000 BCE onwards, the original combined population started to increase, and this is probably also the time when Svalbard was colonized, and the population split took place (Fig. 1).

The combined population continued to increase during the Holocene (from 7,000 years ago until 2,000 years ago), which was probably caused by a combination of new favourable habitats becoming readily available as the ice sheet retreated, such as the formation of intertidal habitats like the Wadden Sea, and anthropogenic positive effects such as deforestation and cultivation providing more habitat in the wintering areas. The analysis suggests a sharp decline in population sizes around 1,500 years ago causing a decimation of the population size which remained consistently low all throughout the Middle Ages until recent times. This abrupt decline cannot be explained by glaciation (the Little Ice Age occurred later between the 16th and 19th centuries) or other

environmental factors but is most likely explained by increased human persecution on the breeding and moulting grounds, including Iceland (Storå 1968; Pujolar et al. 2017). With the invention and common use of firearms for hunting, waterfowl shooting for market sale and own consumption became widespread in Europe from the 18th century onwards, and this probably also contributed to the control of the population of the Pink-footed Goose.

Genetic demographic history analysis cannot make inferences for recent times. The fastsimcole2 simulation method suggests an effective population size of 8,000 individuals for the Iceland population and 2,500 individuals for the Svalbard (br) population in the first half of the 20th century (Fig. 3). Applying a conservative rule of thumb that effective population size is usually about one-fourth of the total census size in birds (Grant & Grant 1992), the results match the observed numbers quite well, viz. c. 20,000-30,000 individuals for the Icelandic and c. 10,000 for the Svalbard census populations in the 1950s (Pujolar et al. 2017).

Census data go back to the 1930s, when the wintering Svalbard (br) population was estimated at 5,000-8,000 individuals (Madsen 1982). Numbers increased to 8,000-12,000 in the 1940s and 1950s, and this increase continued in the 1960s and 1970s. By 1980, the population size had reached 27,000 individuals. The growth continued until the 2010s. Since then, the population size is estimated to have fluctuated between 72,000 and 90,000 in spring (based on an integrated population model; Johnson et al. 2020; Jensen et al. 2023)(Fig. 4). The causes behind the continued increase since the 1940s are mainly attributed to improved protection from hunting, such as ban of spring shooting in Denmark since 1965, a national hunting ban in the Netherlands since 1976 and in Belgium since 1981 (but local bans were instigated from 1958 onwards) (Madsen et al. 1999). The impact of hunting was corroborated by an analysis of ring recoveries showing an increase in adult survival from 1955-1974 to 1975-1983 (Ebbinge et al. 1984). Climate change resulting in milder winters and land use changes (growth of winter cereals and maize) may also have contributed to better winter survival (Kéry, Madsen & Lebreton 2006).

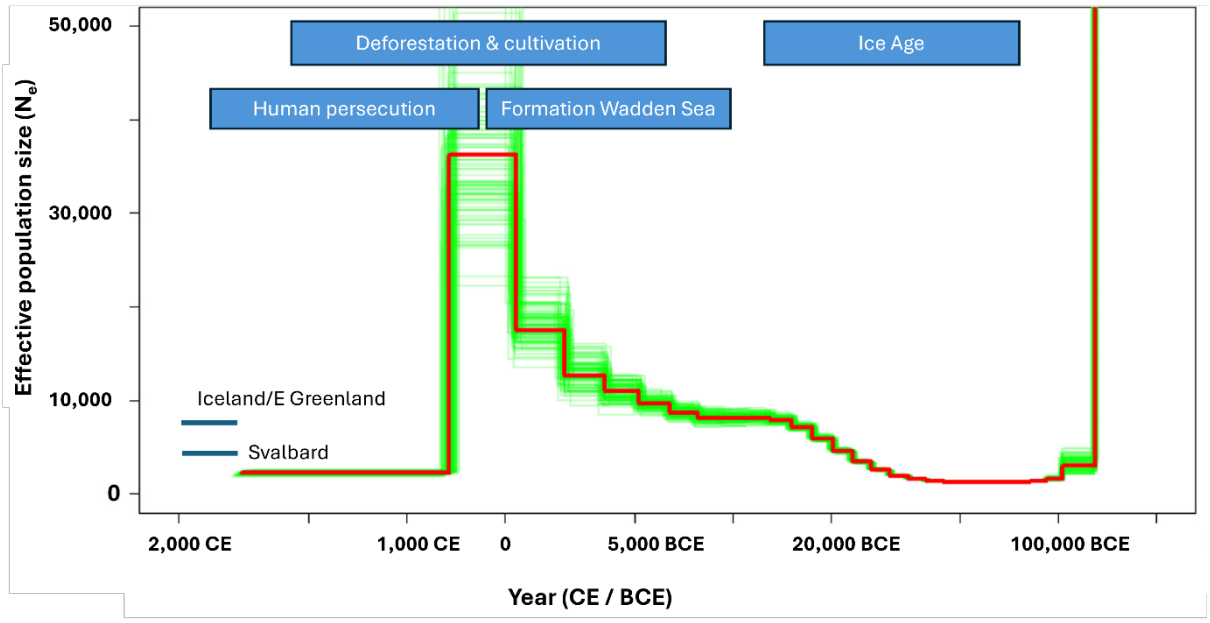



***Figure 3.*** *Reconstruction of the demographic history of the combined population of Pink-footed Goose based on genomic analyses. PSMC estimates of the demographic changes in effective population size, $N_e$) over time: The red curve is the PSMC estimate for the original data, and the green curves indicate PSMC estimates for 100 bootstrapped sequences. Blue lines for the most recent time show inferences from a fastsimcole2 simulation, giving $N_e$ for the Iceland/East Greenland (upper) and the Svalbard (br) populations (lower), respectively. Major periods of environmental and anthropogenic effects are indicated (redrawn from Pujolar et al. 2017).*

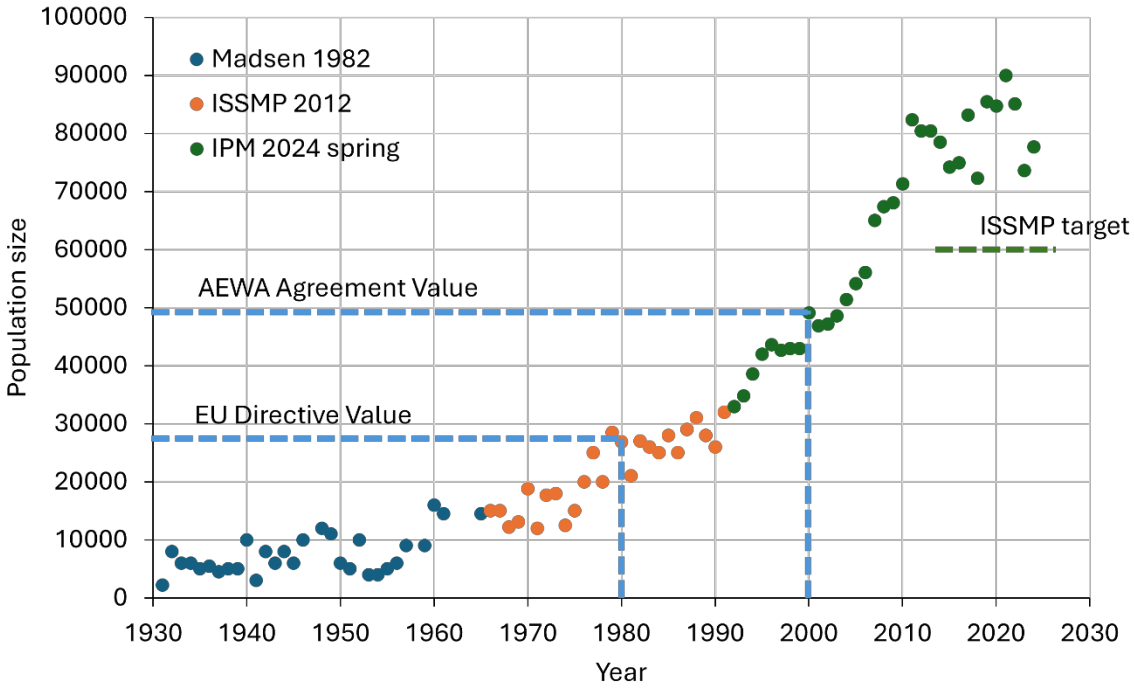



***Figure 4.*** *Trajectory of the Svalbard (br) population of the Pink-footed Goose, 1931-2024, based on censuses (Madsen 1982; ISSMP 2012, referring to Madsen and Williams 2012) and outputs from the integrated population model used to estimate the spring population size under the EGMP (IPM 2024 spring; only median values shown). The population size at the time when the EU Birds Directive and AEWA entered into force are shown. The population target agreed in the 2012 ISSMP for the Pink-footed Goose is also indicated.*

The demographic analyses suggest that the two populations of the Pink-footed Goose were suppressed by human persecution until the first half of the 20th century. One has to be cautious of using the analyses to infer absolute past population sizes. If one assumes that the peak reached around year 0 (Ne c. 35,000; Fig. 1) represents a total population size of 4 x Ne, equivalent to c. 140,000 individuals, this is close to the aggregated census level of the two populations by 1980, i.e., 27,000 + c. 100,000 individuals. The habitat availability and quality in year 0 and 1980 cannot be compared and the argument shall only be seen as a rough judgement suggesting that the numbers of Pink-footed Geese were within the same order as at their (modelled) peak around year 0. By year 2000, the populations were twice as high as in year 0, and by 2020 nearly five times as high.

It is noteworthy that there are no signs of density-dependent regulation of the current population size (based on integrated population simulations; F. Johnson per. comm.). Hence, the current stabilization in population size is primarily an effect of the ongoing adaptive harvest management program controlling the population size, not a sign of carrying capacity being reached.

In summary, within the last 200-300 years, which is the long-term reference period for defining FRP according to EU guidance, the Svalbard (br) population of the Pink-footed Goose has been very low until the mid-1950s. Since then, the population has undergone an eightfold increase, primarily caused by improved protection and facilitated by climate change, and changes in agricultural land use benefitting survival. Currently, the population has been stabilized as a result of an adaptive harvest management program under the EGMP with the objective to maintain a stable population in order to minimize agricultural conflicts and reduce degradation to Arctic tundra due to goose grazing.

## 3. Trend, major shifts, pressures

Both in terms of population size and range there have been increasing trends during the last 50-70 years. The shift to utilization of farmland habitat in the non-breeding range in combination with improved protection has favoured survival rates, fuelling population development. The population has shown an effective and fast adaptation to new foraging opportunities, and this phenotypic flexibility and associated social learning has been key to the success of the population. So far, there are no signs of density dependent regulation at population level, and warming in Svalbard will facilitate further expansion. Furthermore, the recent colonization of Novaya Zemlya and creation of a new migration route is likely to contribute to further increase. The adaptive harvest management program introduced under the 2012 ISSMP has dampened the increase and managed to maintain a stable population size (albeit above the agreed target).

One of the potential pressures on the population is increasing competition for food with the Barnacle Goose. This is manifest in the wintering areas, where the sites used by Pink-footed Geese increasingly become occupied by Barnacle Geese from the Russia, Baltic, Netherlands and Germany population, and it is also manifest on the spring staging grounds in northern Norway which have been occupied by Barnacle Geese from the Svalbard population (Tombre, Eythorsson & Madsen 2013). So far, the Pink-footed Geese have buffered the competition by moving away from the sites occupied by Barnacle Geese, but it may become increasingly difficult to find suitable alternative habitats, because the Barnacle Geese also increase in abundances, range and also quickly adapt to new foraging opportunities.

## 4. Setting Favourable Reference Values

### 4.1 Favourable Reference Population

Since the Pink-footed Geese primarily breed in Svalbard and Novaya Zemlya and with negligible demographic exchange with the Iceland/East Greenland population, the FRP is defined at the biogeographic flyway scale.

The EU guidance (DG Environment, 2023) and previous processes under AEWA have recognized two different approaches to establish FRVs: either a **reference-based approach** based on historic reference levels (comparing the current situation to a more favourable historical situation), or a **population-based approach** based on modelled information for the population. In most cases, e.g., Barnacle Geese and Greylag Geese, historic reference levels are poorly documented, and a population-based approach has been used. However, as stated above, in the case of the Pink-footed Goose, historic records of the population size and trajectories go back to the 1930s, and demographic inference can be made in a longer time perspective based on whole genome and RAD sequencing data generated. Given the long time series and independent sources at hand, it has been decided to rely on the reference-based approach to define the FRP.

Taking into account the available EU guidance, the definition of Favourable Conservation Status in the Convention on Migratory Species (CMS), and the previous processes for defining FRVs under AEWA, the following considerations should be made concerning the Favourable Reference Population (evaluation is written in italics):

1. The Favourable Reference Population should be a viable component of its ecosystem in the long-term[2]. *This appears to be fulfilled. On the breeding grounds in Svalbard, geese play an important role in the ecosystem, foraging on vegetation and modifying vegetation biomass, composition, ecosystem state and functioning, and the geese are important prey of Arctic Foxes. The Pink-footed Goose is regarded as a*

[2] The CMS definition of FCS includes the following element: "population dynamics data indicate that the migratory species is maintaining itself on a long-term basis as a viable component of its ecosystems".

*keystone species in the terrestrial environment of Svalbard (see www.coat.no). The Pink-footed Geese exert an increasing grazing pressure on the tundra, and within the last two decades this has increased with the increasing goose abundances, to an extent that it has raised concerns for the tundra ecosystem function (Madsen & Williams 2012; Ravolainen et al. in prep. cited in Madsen et al. 2024). However, to define how many is enough in order to consider a population to be a viable component of its ecosystem is difficult because of a general lack of scientific understanding of Arctic food web interactions and feedback and the fact that the Arctic environment is undergoing rapid change due to global warming. Hence, habitat availability for geese and their role in the ecosystem are in a transition phase. In the wintering and staging areas, geese mostly feed in agricultural habitats, but also in extensively farmed grasslands. Ecosystem functions provided by the species include grazing effects on vegetation, transfer of nutrients from terrestrial to aquatic systems, as well as transport of seeds etc.*

2. Abundance should approach historic levels as far as it is feasible and consistent with wise wildlife management[3].
   *On the breeding grounds abundances have exceeded historic levels; existing colonies have increased in abundances, and new colonies have been established, both within and outside the traditional range. Outside the breeding season, abundances have increased, and the geese have dispersed to new staging and wintering areas throughout the existing range and beyond.*

3. The Favourable Reference Population should be at least the size when the EU Directive came into force. In previous determinations of FRPs under AEWA it was similarly agreed that, in principle, the FRP should be at least the size when the Agreement came into force.
   *The current population exceeds the size when the Directive came into place and when AEWA came into place (Table 1).*

4. Both DG Environment (2017) and the AEWA Technical Committee (2017) recognise that FRVs do not automatically correspond to the 'potential values' such as carrying capacity, but these should be used to understand restoration opportunities and constraints.
   *The population has not reached carrying capacity; the population is on purpose maintained at a stable level; above the population target at 60,000 ±10,000 agreed in the 2012 ISSMP (which is higher than the Agreement value).*

5. When applying the reference-based approach and the population has not undergone visible shifts or reductions in the past and the current population size is large enough to ensure the long-term viability of the population, DG Environment (2017: p.117) advise that the Favourable Reference Population size should be equal to the current population size except for populations that are secure and have triggered human-wildlife conflict. In that case, the FRP should be lower than the Current Value. Further, according to the CMS definitions: 'the distribution and abundance of the migratory species approach historic coverage and levels to the extent that potentially suitable ecosystems exist and to the extent consistent with wise wildlife management'.
   *The population of the Pink-footed Goose is subject to an ISSMP with (among others) the purpose to reduce human-wildlife conflicts and ecosystem impacts; in this case it is therefore an option to define the FRP below the current population level.*

[3] The CMS definition of FCS includes that: "the distribution and abundance of the migratory species approach historic coverage and levels to the extent that potentially suitable ecosystems exist and to the extent consistent with wise wildlife management".

***Table 1.*** *Population reference values for the Svalbard (br) population of the Pink-footed Goose.*

| | |
|---|---|
| Historic known value (1930s) | 8,000 (spring) |
| EU Birds Directive value (1980) | 27,000 (spring) |
| AEWA Agreement value (2000) | 49,000 (spring) |
| ISSMP Target (2012) | 60,000 (±10,000) (spring) |
| Current value (spring 2024) | 78,000 (spring) |

Taking the above factors into consideration, and applying a reference-based approach, the revised ISSMP sets the FRP for the Svalbard (br) population of Pink-footed Goose at a spring population of 49,000 individuals, i.e., the closest available value after the date that AEWA entered into force on 1 November 1999.

## 4.2 Favourable Reference Range

According to the EU and CMS definitions, the range of a population should be large enough to maintain the FRP and address any deficiency in the historic range. During the last 50-70 years, the range of Pink-footed Geese has expanded in the breeding as well as the non-breeding areas. The new group established in Novaya Zemlya, which is currently in exponential growth (based on spring counts in Finland and autumn counts in Sweden; EGMP online data portal), adds a new dimension to the overall range, and it appears that there are ample opportunities for further expansion along the new route.

At the FRP of 49,000, which was reached in 2000 after AEWA came into force, the Novaya Zemlya breeding grounds and the stopover sites in Finland, Sweden and SE-Denmark had not yet been established. Even without considering the new migration route, the range along the traditional flyway expanded during 2001-2024. Hence, the range has not been limited, despite the population increase along the traditional flyway.

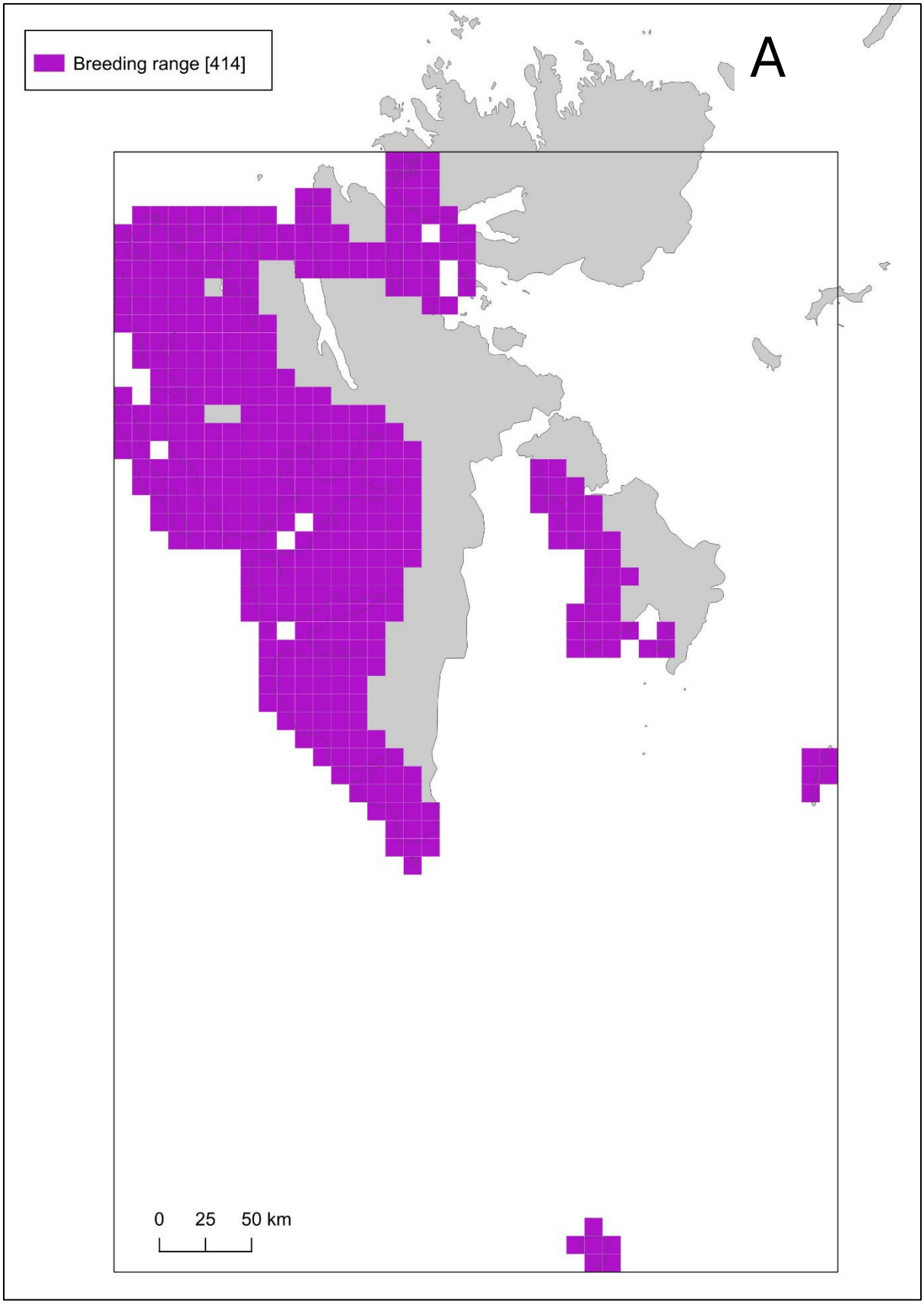
The range around year 2000 has been used for calculating the FRR. To do this, we have used four sources of information:

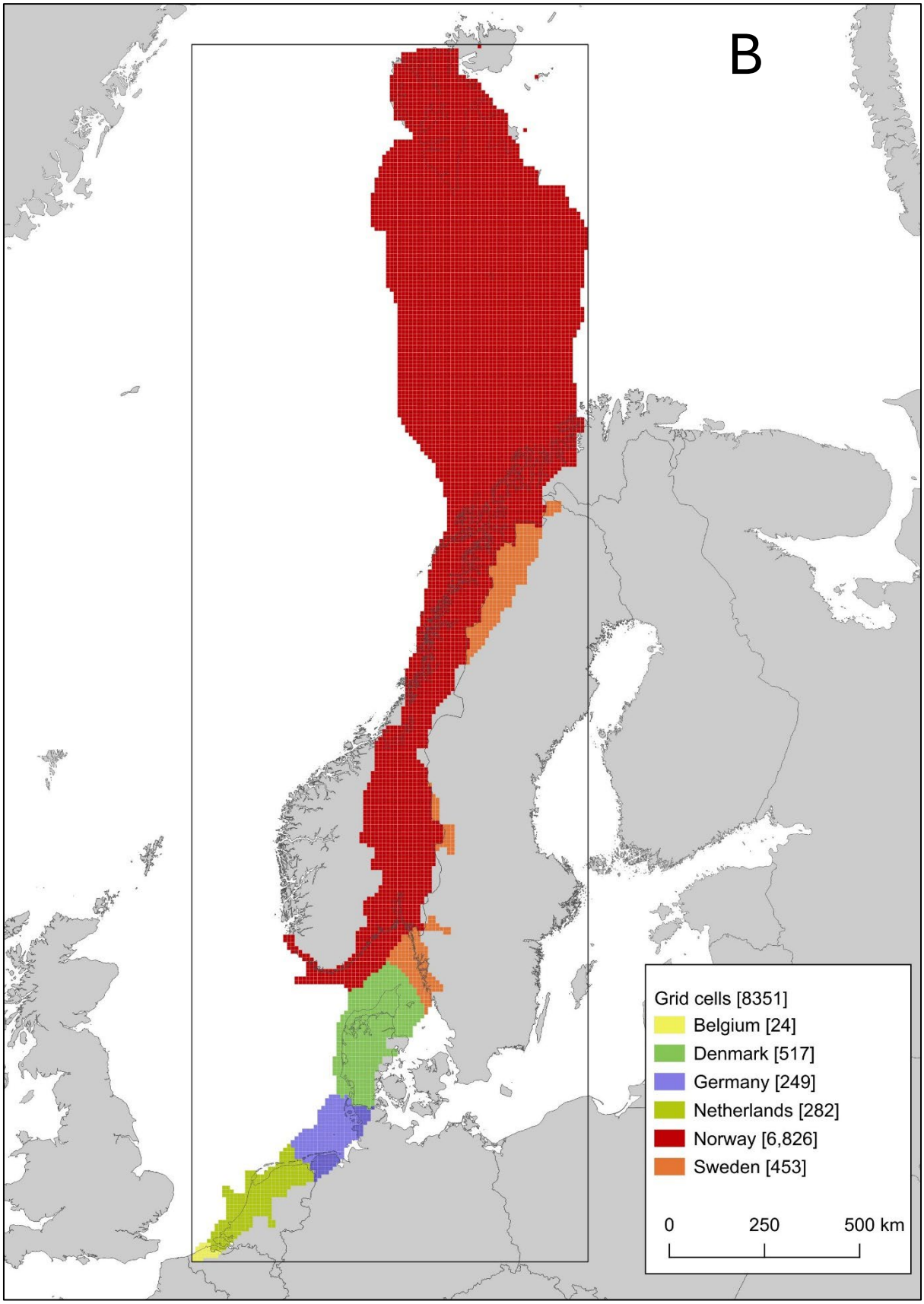
1. Breeding range in Svalbard based on GOOSEMAP (2012), which is a compilation of spatial data from several decades about pre-nesting, nesting and brood-rearing distribution up until around 2011. Furthermore, non-breeding range in Svalbard was mapped based on moulting and post-breeding distributions.
2. Resightings of neck-banded individuals along the flyway during 1998-2002 (5 years, totalling 79,204 records), based on marking primarily undertaken in Denmark in spring (Aarhus University; data repository under https://submit.cr-birding.org/).
3. GPS-tracking of individuals marked and tagged in Svalbard in 2018 (29 individuals, mostly adult females caught during brood rearing in two sites in Isfjorden). This dataset was used because it is the only source which can inform about post-breeding range use in Svalbard and migration path range for sea crossing or migration over remote areas. We used tracking data from 2018 to 2024, producing a total of 64,545 GPS-positions. For this analysis, we excluded geese which used the Swedish-Finnish migration route, which was not yet established in year 2000. Hence, it is believed that the tracking represents the migration pathways, and there is a good correspondence between the tracking positions and the neckband resightings for geese on the ground.
4. Citizen science reports of staging and migrating flocks of geese in the non-breeding season. This was used to fill gaps in the coverage of resightings of neckbands and GPS-tracks in selected areas such as southwest Norway (using the portal artsobservasjoner.no).

We followed the guidelines for mapping range proposed by the EU (Bijlsma et al. 2019, DG Environment 2023), using a 10 km x 10 km grid. For resightings and GPS-tracks, we only regarded a grid cell as used, if we have at least two independent records from the grid cell. For the breeding range calculations, we included the home

range and dispersal distance as advocated by Bijlsma et al. (2019). We have included the migration corridors across open sea and mountains as part of the range. In this presentation, we have not separated between geese recorded on the ground or passing. Because the tagged geese may accidentally not have passed over all grid cells in the non-breeding range, we drew an outer polygon around the tracks at sea and land, and grid cells not used by geese inside the polygon were filled.

In Fig. 5, three maps present the FRR (in 10 km x 10 km grid cells) for (1) the breeding grounds in Svalbard, before the colonization of Novaya Zemlya and excluding scattered nesting pairs in North Norway, (2) the non-breeding grounds prior to the establishment of the new migration route through Russia, Sweden, Finland and SE-Denmark, including or excluding migration over sea, i.e., the Barents Sea, Skagerrak and the southwestern North Sea.


Breeding range [414]
A
0 25 50 km


B
Grid cells [8351]
Belgium [24]
Denmark [517]
Germany [249]
Netherlands [282]
Norway [6,826]
Sweden [453]
0
250
500 km

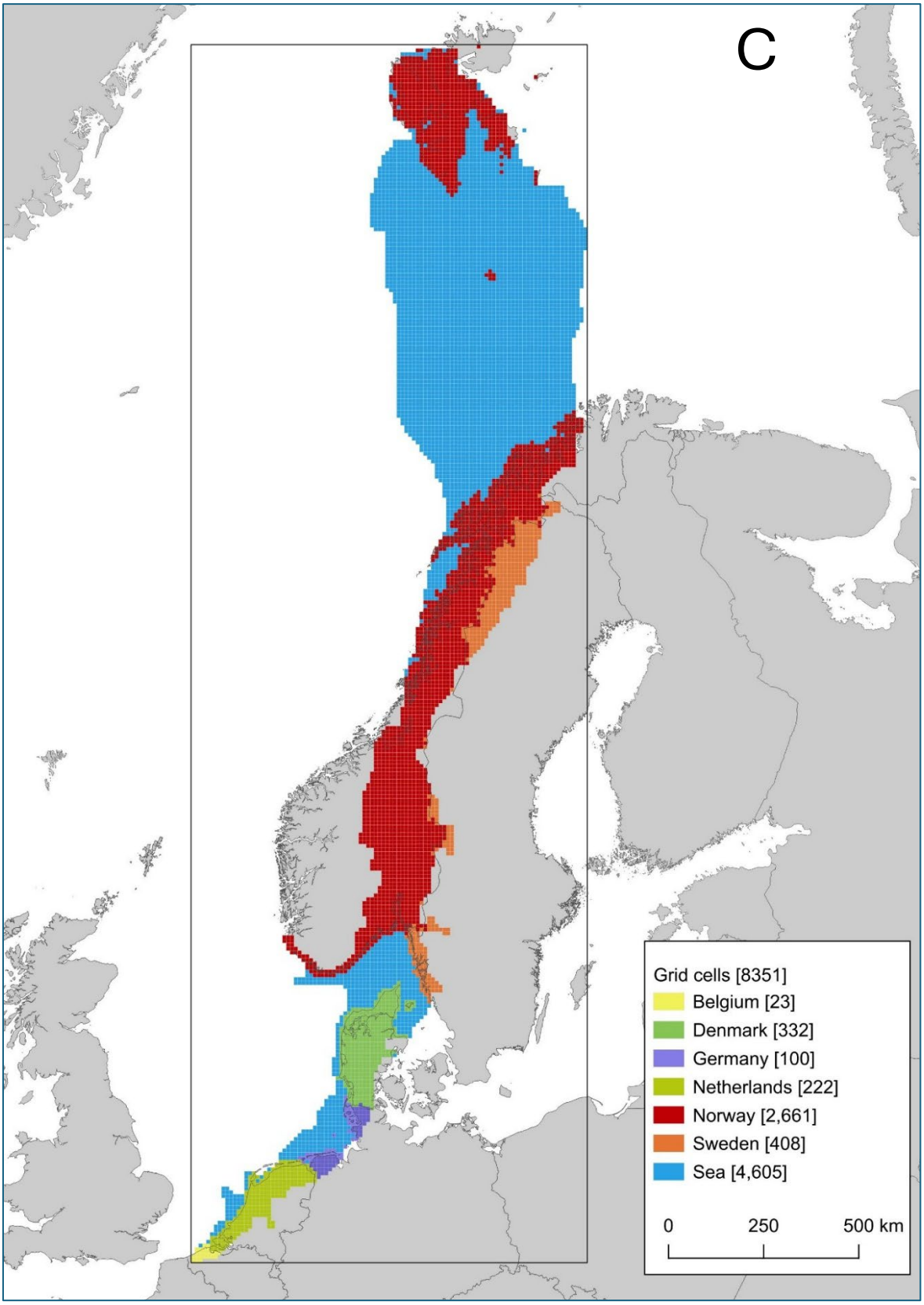



***Figure 5.*** *Proposed Favourable Reference Range for the Svalbard (br) population of the Pink-footed Goose. A: Breeding grounds, B: Non-breeding area, divided into sea (used as migration path) and land (used for passage and roosting / foraging) per country and, C: Non-breeding area, divided into land per country and sea for the entire range. Numbers in parenthesis show the number of 10 km x 10 km grid cells used by the geese in the range states. The FRR reflects the situation around 2000 when the AEWA Agreement came into force. The broad range by sea-crossing the Barents Sea reflects that geese drift over wide areas caused by strong winds (Geisler et al. 2022).*

Table 2 summarises the FRR for each country used by Pink-footed Geese according to the above analysis.

***Table 2.*** Proposed Favourable Reference Range (in km$^2$) for the Svalbard (br) population of the Pink-footed Goose around year 2000 Range covering sea represents migratory range overseas.

| | Breeding | Non-breeding (land) | Non-breeding (land and sea) |
|---|---|---|---|
| Norway | 41,400 | 266,100 | 682,600 |
| Denmark | | 33,200 | 51,700 |
| Sweden* | | 40,800 | 45,300 |
| Germany** | | 10,000 | 24,900 |
| The Netherlands | | 22,200 | 28,200 |
| Belgium | | 2,300 | 2,400 |
| Total | 41,400 | 374,600 | 835,100 |

*Note: *most of the Swedish land range consists of the migratory path. Around year 2000 Sweden was not regarded as a principal range state (however, has become more important since then). **most of the German land range consists of the migratory path. Germany is not regarded as a principal range state.*

## 4.3 Favourable Reference Habitat

According to the EU and CMS definitions, the FRH means that there is sufficient extent and quality of habitat to sustain the FRP. In the breeding range in Svalbard, the pre-nesting, nesting and brood-rearing habitats appear to be sufficient to support the current population size; however, there is a risk that the increasing abundances of geese can cause a change of the moss-dominated tundra, which may affect the ecosystem functions and reduce the habitat capacity for geese; this may have implications for local carrying capacity, but the geese continue to expand their range in Svalbard (and Novaya Zemlya), indicating that there is sufficient habitat for even further increase in overall population size.

In the non-breeding range, Pink-footed Geese have switched from foraging in seminatural habitats to intensive farmland; only in some areas like the polder area in Flanders, the geese continue to forage in extensively farmed wet grasslands, especially in protected sites such as SPAs or nature reserves. The shift does not appear to be caused by lack of seminatural grassland habitat (Lorenzen and Madsen 1985) but rather that the geese prefer farmland habitats because these are more favourable in energetic terms (Madsen 1985; Therkildsen and Madsen 2000; Clausen et al. 2018b). Both in the wintering and spring staging areas, there appears to be sufficient habitat for even further increase in population size.

To conclude, as the current population size exceeds the FRP and there is no sign of density dependence, it can be logically deduced that there is sufficient habitat to sustain an even larger population than the FRP.

## 4.4 Proposed Favourable Reference Values

According to the reference-based approach to define FRP for the Svalbard (br) population of the Pink-footed Goose, the revised ISSMP for this population sets the FRP at a spring population size of 49,000 individuals, i.e., the closest available value after the date that AEWA entered into force on 1 November 1999. By that time, the population was flourishing in exponential growth and was expanding its range on the breeding and non-breeding grounds. Habitat was not limiting the population, as new habitat became available on the breeding grounds due to global warming as well as on the non-breeding grounds due to beneficial changes in agricultural land use practices. At the Agreement Value the population plays a key role in the Arctic ecosystems. The increasing abundances exert an increasing grazing pressure on the Svalbard tundra, of concern to its ecosystem functions. In the non-breeding range, the population is heavily reliant on artificial agricultural habitat, which has caused socio-economic conflicts. The range used in 2000 was sufficient to maintain the population and its ecosystem

services throughout the annual cycle, including opportunities for recreational observation and use. See Table 2 for the FRR.

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UNEP/AEWA Secretariat
UN Campus
Platz der Vereinten Nationen 1
53113 Bonn
Germany
Tel.: +49 (0) 228 815 2413
Fax: +49 (0) 228 815 2450
aewa.secretariat@unep-aewa.org
www.unep-aewa.org